Space Weather Technical Forecast

Issued on Monday 16 December 2024 at 13:19 Local

This technical forecast provides a four-day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

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Space Weather Forecast Headline: A chance of isolated R1/R2 Radio Blackouts, becoming likely by Day 3 (18 Dec).

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Moderate following an impulsive M3.1 flare at 15/2024 UTC from AR3920. There are currently five sunspot regions on the Earth-facing disc with AR3924 in the southwest disc, the largest and most complex region. The remaining regions on the disc are smaller and more magnetically simple.

A filament eruption was observed around 15/0400 UTC from a region to the southeast of AR3924. Some coronal dimming was evident in GOES SUVI-195 imagery and a faint 'partial halo' CME was indicated in STEREO A COR 2 imagery and to a lesser degree in LASCO C2/C3 imagery. A possible glancing blow to Earth, but more likely a hit to STEREO A, ahead of Earths orbit.

Solar Wind / Geomagnetic Activity: Solar winds, as reported by ACE at L1, showed a gradual slowing of the solar wind speeds from slightly elevated to slow-ambient as the connection to the HSS from CH99+ declines. Solar wind speeds peaked at 450km/s from around 15/2000 UTC falling to 390 km/s from 16/0800 UTC. Density was generally around average. The Interplanetary Magnetic Field (IMF), Bt, was weak at first, before becoming moderate between 15/2100 to 16/0600 UTC, after which it became weak again. The north-south component, Bz, oscillated between positive and negative, but generally favoured a weakly negative direction. Over the whole period it varied between +5/-7nT. The phi angle was generally positive (away from the Sun), aside for a brief negative (towards the sun) interval between 16/0400 and 16/0600 UTC. The net result of the above solar wind measures was for Quiet to Unsettled geomagnetic activity (Kp1-3).

Energetic Particles / Solar Radiation: High energy proton flux observed by GOES18 was at background levels. High energy electron flux (greater than 2MeV) observed by GOES16 was mainly background. The associated 24-hour fluence was below Active, on a declining, then largely steady trend. The 16/0000 UTC observation was 1.16e6 integrated pfu.

Four-Day Space Weather Forecast Summary

Solar Activity: Low to Moderate Solar activity is expected with a chance of M-class flares on Days 1 and 2 (16 and 17 Dec). M-class flares then becoming likely by Day 3 (18 Dec). There is a slight chance of isolated X-class flares throughout.

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Solar Wind / Geomagnetic Activity: A CME that left the Sun on 15 Dec may see a glancing blow to Earth on Days 3 and 4. Otherwise a declining connection to the high-speed stream of CH99 is expected to see solar wind speeds ease from slightly elevated to slow-ambient levels between Days 1 and 2 (16 and 17 Dec), with no further coronal hole enhancements expected during the period.

Geomagnetic activity is expected to be mainly Quiet to Unsettled, with a slight chance of isolated Active intervals between Days 1-2 (17-18 Dec). Any influence from the CME that left the Sun on the 15 Dec may see geomagnetic activity increase, with periods of Unsettled to Active and a slight chance of G1/Minor Storms from Day 3 (18 Dec).

Energetic Particles / Solar Radiation: High energy proton flux is expected to remain at background, but with a slight chance of rising in response to any notable flares. High energy electron flux is expected to be at background to moderate levels. The 24-hour fluence is expected to remain below the Active threshold.

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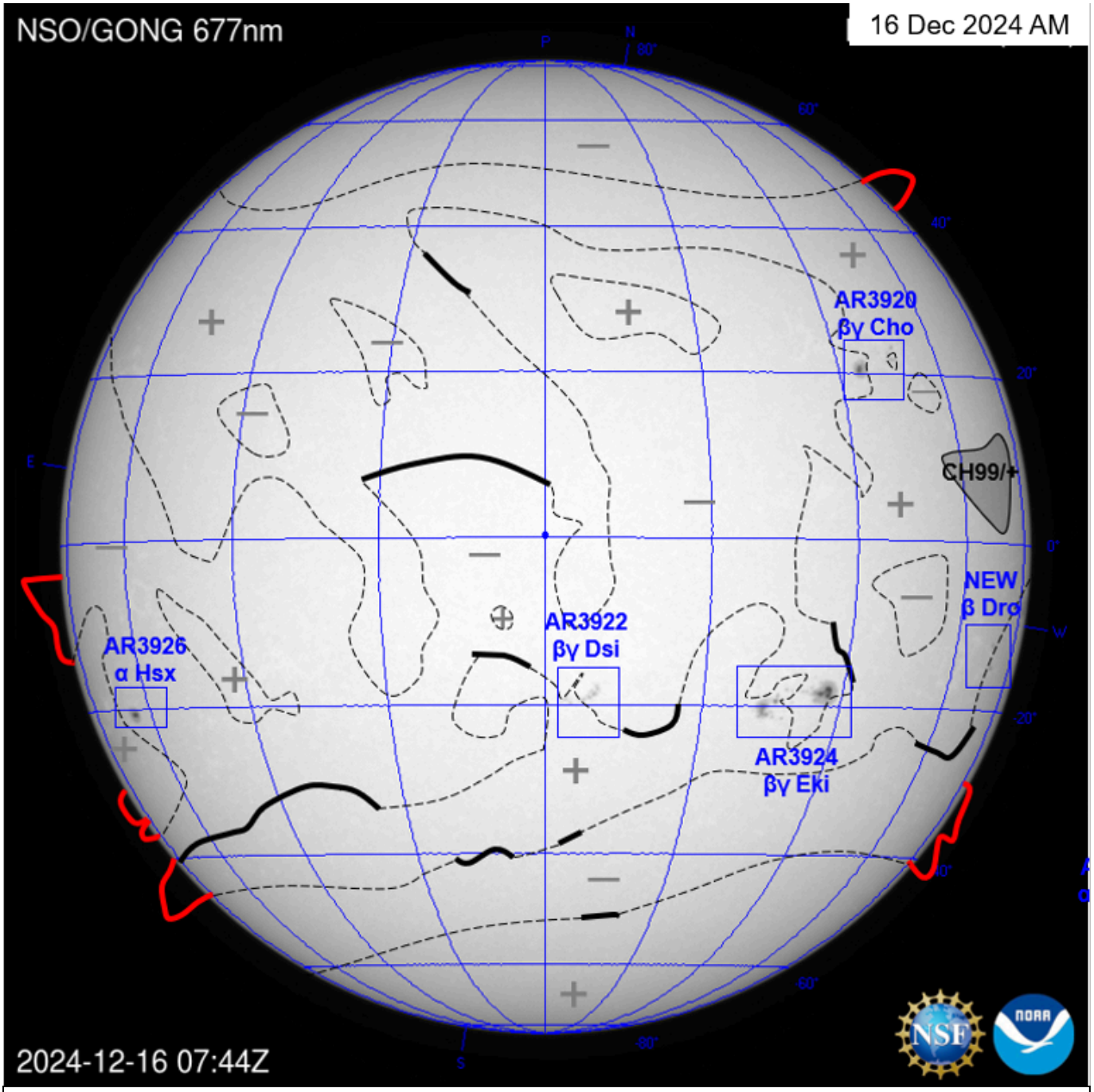
Figure 1: Solar Synoptic Map valid 16/0744 UTC



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms

A CME associated with a large filament eruption in the southwest of the disc late 14 Dec is expected to pass mostly ahead and below Earth's orbit. This was shortly followed by a potentially more significant filament eruption around 15/0400 UTC from a region to the southeast of AR3924. Some coronal dimming was evident in GOES SUVI-195 imagery and a faint 'partial halo' CME was indicated in STEREO A COR 2 imagery and to a lesser degree in LASCO C2/C3 imagery. This looks to again largely pass ahead of Earths orbit, reaching STEREO A on Day 3 (18 Dec) or possibly into Day 4 (19 Dec) with a slight chance of a glancing blow at Earth.

The coronal hole-based forecast carries much higher confidence. The connection to CH99+ which brought elevated wind speeds over the weekend (UTC) appears to be waning with solar wind speeds showing a gradual decline though Days 1 and 2 (16 and 17 Dec). No further coronal hole enhancements are anticipated through the remainder of the forecast period. MOSWOC ENLIL output is too slow to ease the high-speed stream from CH99/+. Furthermore, a stronger enhancement between Days 2-4 (17-19 Dec) has no observable source region currently on the visible disc. This is consequently considered anomalous and disregarded at this stage. The results of this erroneous elevated wind speed may result in any CME material being shown to arrive too early.

Geomagnetic activity is expected to be mainly Quiet to Unsettled, with a slight chance of isolated Active intervals between Days 1-2 (17-18 Dec). Any influence from the CME that left the Sun on the 15 Dec may see geomagnetic activity increase, with periods of Unsettled to Active and a slight chance of G1/Minor Storms from Day 3 (18 Dec).

Geomagnetic Storm	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Minor or Moderate	G1 to G2	No	5	5	20	10
Strong	G3	No	1	1	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

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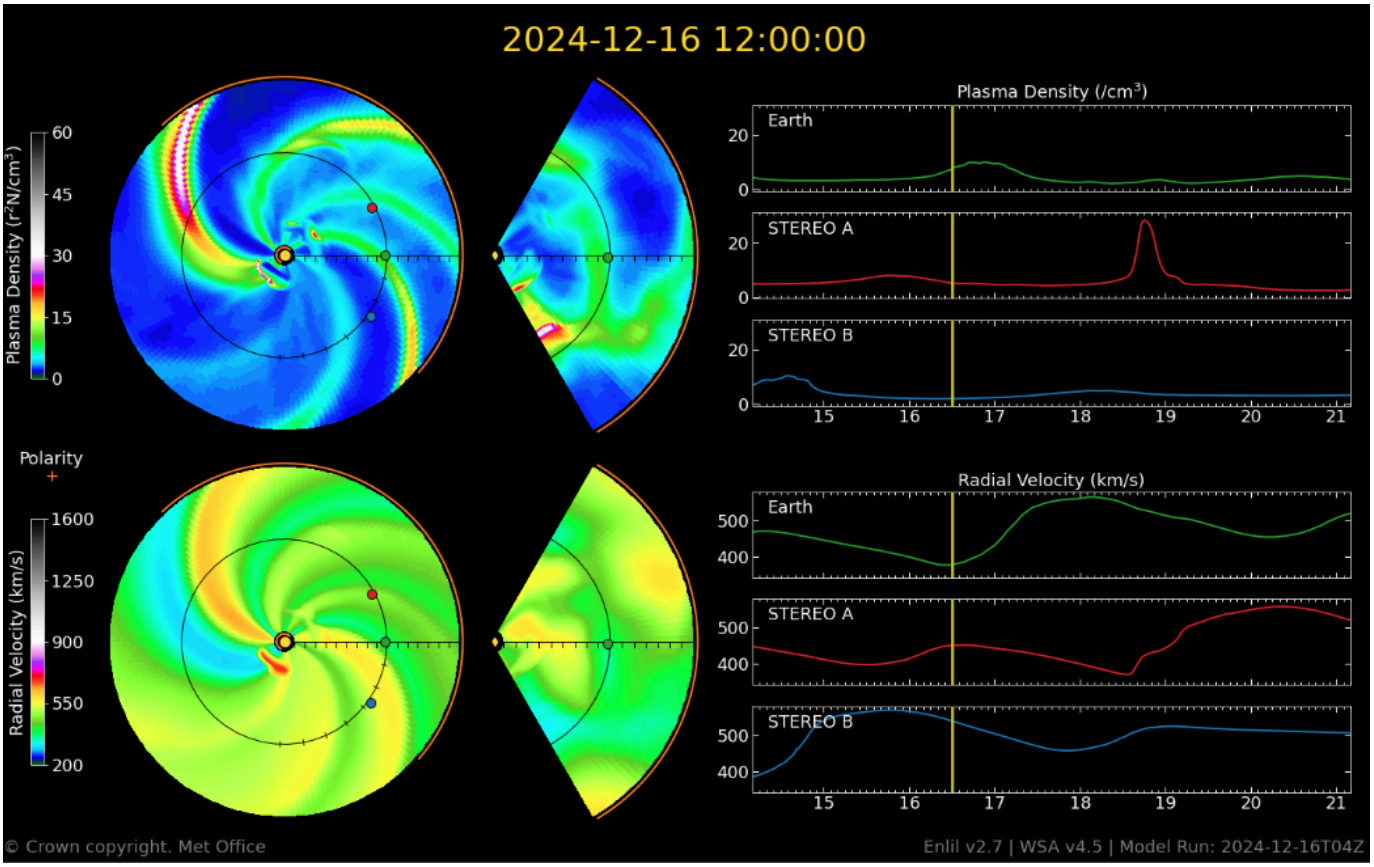
Figure 2: MOSWOC Enlil output.



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Radio Blackouts - X-Ray Flares

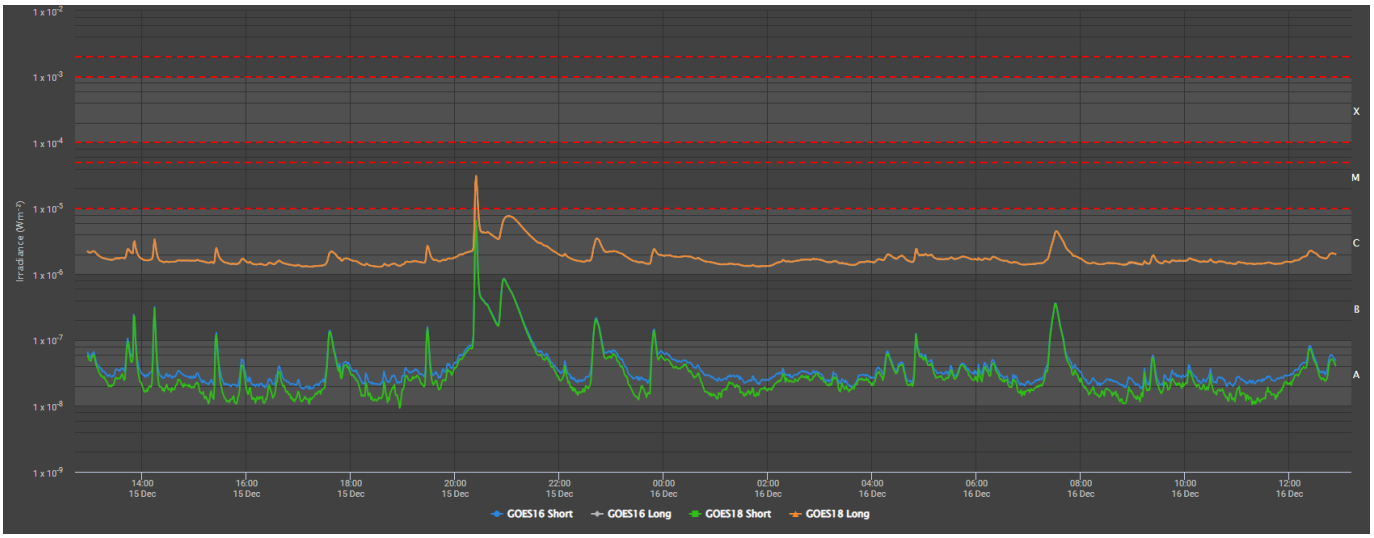
Solar activity is currently at Moderate levels following an impulsive M3.1 flare at 15/2024 UTC from AR3920. There are currently five sunspot regions on the Earth-facing disc with AR3917 having recently rotated around the western limb, however it remains possible to produce further C-class flare activity. AR3924 in the southwest disc, is the most complex region and consists of a mature leading region with split umbra and a smaller, irregularly shaped main trailing region with proliferation of numerous small spots surrounding it. AR3920 provided the most recent M-class flare, with evidence of small spots of mixed polarity in its leading region. The remaining regions on the disc are smaller and more magnetically simple.

There continues to be the likelihood for further regions to rotate onto the disc from over the east limb between Days 2-4 (17-19 Dec) corresponding to Ex-AR3902, Ex-AR3905 and Ex-AR3906. The latter two produced M-class flares when they were last on the facing-disc and recent far-sided CME activity and helio-seismic soundings suggest that at least one of these regions remains active.

Overall Low to Moderate Solar activity is expected with a chance of M-class flares on Days 1 and 2 (16 and 17 Dec). M-class flares then becoming likely by Day 3 (18 Dec). There is a slight chance of isolated X-class flares throughout.

X-Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 (M Class)	Yes	45	50	55	60
Very Active	R3-R5 (X Class)	No	5	5	5	10

Figure 3: GOES16 & 18 X-ray trace.



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Solar Radiation Storms (High Energy Protons)

GOES18 proton flux carries a daily slight chance of reaching S1/Minor Storm levels or greater from any significant solar flares. Proton enhancements are most likely from AR3917, but the region will rotate over the western horizon by Day 2 (17 Dec), with risks reducing slightly later in the period pending developments of the other sunspot regions currently on the farside of the disc.

Radiation Storms Probability (Exceedance)	Level ($cm^{-2}sr^{-1}s^{-1}$)	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	No	15	15	10	10
Very Active	**≥ S3 ***	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and/or 50 MeV ≥ 10pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

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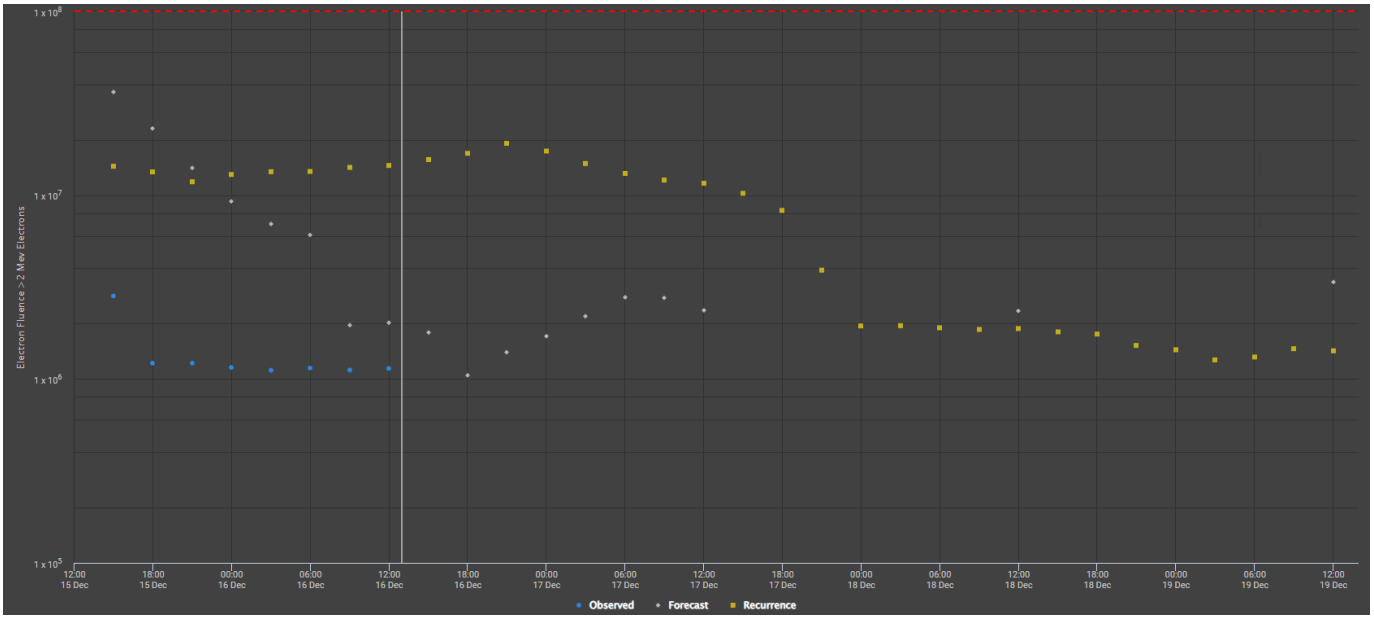
High Energy Electrons (≥ 2MeV)

High energy electron flux observed by GOES16 has been largely at background levels following the influence of the HSS from CH99+. Electron flux may see moderate peaks in the diurnal cycle for a time between Days 1 and 2 (16 and 17 Dec), before likely reverting to background levels again on Day 3 (18 Dec) due to anticipated CME influence.

The associated 24-hour fluence is well below the Active (1e8 integrated flux) threshold, on a steady trend and expected to remain below this level throughout the forecast period. The MO REFM output is providing reasonable guidance.

GEO Electron Environment	Level ($cm^{-2}sr^{-1}$ day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Active	≥ 2 MeV ≥ 1×10^{8}	No	1	1	1	1
Very Active	≥ 2 MeV ≥ 1×10^{9}	No	1	1	1	1

Figure 4: MOSWOC REFM output.



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